Planetary Raman Spectroscopy: Sciences and Instrumentation

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In a surface investigation on Mars or Moon or Venus, a key priority should be definitive identification and characterization of surface materials (e.g., definitive mineralogy or other species), which will improve our understanding of the evolutionary history of the planets. We have been developing a miniaturized laser Raman spectrometer for *in situ* analyses for planetary surface explorations -- the Mars Microbeam Raman Spectrometer, MMRS. We are also developing strategies to use Raman spectroscopy as a stand-alone technique and to be used synergistically with other *in situ* analysis methods in future planetary missions. Through studies of Martian meteorites and terrestrial analogs, we are gaining experience of what compositional and structural information can be obtained on key mineral groups using *in-situ* Raman measurements. We are developing methods for determining mineral proportions in rocks or soils and identifying rock types from sets of closely spaced, rapidly acquired spectra. We are studying how weathering and alteration affect the Raman and luminescence features of minerals and rocks, and we are investigating the Raman characteristics of biogenic organisms and their remains. These studies form the scientific basis for in-situ planetary Raman spectroscopy.

The Neutron Spectrometer on the Lunar Prospector orbiter has found abundant WEH (Water Equivalent Hydrogen) in permanently shaded craters in regolith at the Polar Regions of the Moon. Robots, and eventually humans, will go back to the Moon, this time to explore the Polar Regions and more importantly, to develop the technologies needed to use lunar resources as the basis for further missions to Mars and beyond. The questions posted for the next landed mission to the Moon are (1) in what form is the H? Is it as solar-wind-implanted H^+, water-ice left by cometary impacts, or as H2O/OH structurally bonded to minerals? (2) how can we effectively extract the hydrogen for ISRU purposes? Planetary Raman spectroscopy can address the first question by detecting the characteristic Raman peaks of H_2 (after heating the surface soils), water-ice, and H2O/OH-bearing minerals. Planetary Raman spectroscopy can address the second question using a process-control Raman sensor on ISRU platforms. In addition to H_2, O2 extracted from lunar regolith for propellants can also be detected (both are IR-inactive).

For Venus exploration, Raman spectroscopy will contribute in determining the profile of gaseous species in Venus atmosphere, as well as the definitive mineralogy at surface.